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Review Article

Recent Advancements in Herbal Formulations for the Management of Polycystic Ovarian Disease (PCOD): A Comprehensive Review

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Polycystic Ovarian Disease (PCOD), also known as Polycystic Ovary Syndrome (PCOS), is one of the most prevalent endocrine disorders affecting women of reproductive age, with a global prevalence ranging from 6% to 26%. It is characterized by hormonal imbalances, irregular menstrual cycles, hyperandrogenism, polycystic ovaries, and metabolic dysfunction including insulin resistance and dyslipidemia. Conventional pharmacological therapies, such as oral contraceptive pills, metformin, and clomiphene, are associated with several adverse effects and high costs, leading to increased interest in herbal and plant-based therapeutics. This review comprehensively evaluates the recent advancements in herbal formulations for the management of PCOD, focusing on evidence-based studies from 2015 to 2024. Herbs including Vitex agnus-castus, Cinnamomum zeylanicum, Trigonella foenum-graecum, Glycyrrhiza glabra, Berberis aristata, Curcuma longa, Mentha spicata, and various polyherbal formulations have demonstrated significant efficacy in regulating hormonal profiles, improving insulin sensitivity, reducing androgen levels, and restoring ovarian morphology. The pharmacological mechanisms underlying these effects, including anti-androgenic, anti-inflammatory, antioxidant, and insulin-sensitizing activities, are discussed. The review also highlights recent nanoformulation-based delivery systems for enhanced bioavailability of herbal actives. Future research directions, challenges in standardization, and regulatory perspectives are addressed. Herbal formulations represent a promising, safe, and cost-effective therapeutic avenue for PCOD management.

Keywords: PCOD, PCOS, Herbal formulations, Phytotherapy, Polycystic ovary, Insulin resistance, Hyperandrogenism.

INTRODUCTION

Polycystic Ovarian Disease (PCOD) is a complex, multifactorial endocrine disorder that affects approximately 8–13% of women of reproductive age worldwide [1]. It is one of the leading causes of female infertility and is associated with significant metabolic, reproductive, and psychological morbidities [2]. The pathophysiology of PCOD is heterogeneous and involves a constellation of hormonal dysregulation including elevated luteinizing hormone (LH), increased androgen production, relative follicle-stimulating hormone (FSH) deficiency, and insulin resistance [3]. The clinical manifestations of PCOD are diverse and include oligomenorrhea or amenorrhea, anovulation, hirsutism, acne, alopecia, and weight gain. The metabolic complications encompass type 2 diabetes mellitus, cardiovascular disease, non-alcoholic fatty liver disease, and endometrial carcinoma [4]. The diagnosis is primarily based on the Rotterdam criteria (2003), which require at least two of the following three features: oligo- or anovulation, clinical or biochemical signs of hyperandrogenism, and polycystic ovarian morphology on ultrasound [5]. Current standard therapies include lifestyle modifications, oral contraceptive pills (OCPs), progestins, anti-androgens (spironolactone, flutamide), insulin sensitizers (metformin, thiazolidinediones), and ovulation induction agents

(clomiphene citrate, letrozole). Despite their efficacy, these therapies are burdened with significant adverse effects, contraindications, and high recurrence rates upon discontinuation [6]. This has driven increasing interest in complementary and alternative medicine (CAM), particularly herbal therapeutics, which have been used in traditional medical systems such as Ayurveda, Traditional Chinese Medicine (TCM), and Unani for centuries [7]. Recent years have witnessed a surge in scientific investigation into the phytopharmacological mechanisms of various medicinal plants and their formulations for PCOD management. Advances in nanotechnology have further enabled enhanced delivery of herbal bioactives with improved bioavailability and targeted action [8]. This review aims to consolidate recent advancements in herbal formulations for PCOD, with a critical appraisal of preclinical and clinical evidence, pharmacological mechanisms, and future research perspectives.

Epidemiology and Pathophysiology Of PCOD

PCOD affects women globally with reported prevalences varying by diagnostic criteria and population studied. Using the Rotterdam criteria, prevalence ranges from 15–20% in some populations, while the NIH criteria yield lower estimates of 6–8% [9]. In India, the prevalence has been reported to be as high as 22.5%, making it a significant public health concern in South Asian populations [10]. The pathophysiology of PCOD is multifactorial and involves a complex interplay of genetic predisposition, neuroendocrine dysregulation, insulin resistance, and ovarian dysfunction. Insulin resistance, present in 50–70% of PCOD patients, stimulates excess androgen production from the ovarian theca cells and reduces hepatic sex hormone-binding globulin (SHBG) synthesis, thereby increasing free androgen levels [11]. Hyperandrogenism in turn disrupts follicular development, leading to follicular arrest and the characteristic polycystic morphology. Chronic low-grade inflammation and oxidative stress further perpetuate the hormonal and metabolic derangements [12].

Recent Advancements in Herbal Formulations For PCOD

Vitex agnus-castus (Chasteberry)

Vitex agnus-castus, commonly known as chasteberry or monk's pepper, is one of the most extensively studied herbs for female reproductive disorders. Its active constituents include iridoid glycosides (agnuside, aucubin), flavonoids (casticin, vitexin), and diterpenes. The herb exerts dopaminergic activity by binding to D2 receptors in the pituitary, thereby reducing prolactin secretion and normalizing LH/FSH ratios [13]. A randomized controlled trial by Arentz et al. (2017) demonstrated significant improvements in menstrual regularity, anti-Mullerian hormone (AMH) levels, and psychological wellbeing in PCOD patients receiving standardized Vitex extract [14]. Recent nanoparticle-encapsulated Vitex formulations have shown enhanced intestinal absorption and prolonged therapeutic effects in murine PCOD models [15].

Cinnamon (*Cinnamomum zeylanicum*)

Cinnamomum zeylanicum (true cinnamon) and C. cassia have demonstrated significant insulin-sensitizing properties attributed to their polyphenolic content, particularly cinnamaldehyde, cinnamic acid, and type-A procyanidins. These compounds activate GLUT-4 translocation, enhance insulin receptor signaling, and inhibit protein tyrosine phosphatase 1B (PTP1B), thereby improving peripheral glucose uptake [16]. A systematic review and meta-analysis by Hajimonfarednejad et al. (2021) confirmed that cinnamon supplementation significantly reduced fasting blood glucose, HOMA-IR, LH, testosterone, and lipid parameters in women with PCOS [17]. Nanostructured lipid carriers (NLC) containing cinnamon oil have been developed with improved stability and anti-inflammatory efficacy compared to conventional formulations [18].

Fenugreek (*Trigonella foenum-graecum*)

Trigonella foenum-graecum (fenugreek) seeds contain steroidal saponins (diosgenin, tigogenin), flavonoids, and the amino acid 4-hydroxyisoleucine, which stimulates insulin secretion in a glucose-dependent manner. Diosgenin, structurally similar to progesterone, has demonstrated anti-androgenic and ovarian-protective effects in letrozole-induced PCOD rat models [19]. A clinical study by Neelakantan et al. (2022) reported that a proprietary fenugreek extract

(Furocyst) significantly reduced the number and size of ovarian cysts, restored menstrual regularity, and improved hormonal parameters in PCOD patients after 90 days of supplementation [20]. Phytosomes of fenugreek have shown superior bioavailability and pharmacodynamic efficacy compared to crude extracts [21].

Licorice (*Glycyrrhiza glabra*)

Glycyrrhiza glabra contains glycyrrhizin, glycyrrhetinic acid, and isoflavones that exhibit significant anti-androgenic activity by inhibiting 17-hydroxysteroid dehydrogenase (17-HSD) and 3β-HSD enzymes involved in androgen biosynthesis [22]. Glycyrrhetinic acid has also demonstrated inhibition of 11β-HSD type 1, thereby reducing local cortisol action and improving insulin sensitivity. Rasool et al. (2023) reported that a polyherbal Ayurvedic formulation containing Glycyrrhiza as a principal ingredient significantly reduced testosterone, LH, and improved the LH/FSH ratio in PCOD patients compared to placebo [23]. Licorice-incorporated transdermal patches have been investigated as innovative delivery systems for sustained anti-androgenic action [24].

Berberine (*Berberis aristata* and *Coptis chinensis*)

Berberine, an isoquinoline alkaloid derived from Berberis aristata (Indian barberry) and Coptis chinensis, has emerged as one of the most promising phytochemicals for PCOD management. Berberine activates AMP-activated protein kinase (AMPK), reduces hepatic gluconeogenesis, improves insulin receptor substrate-1 (IRS-1) signaling, and reduces intestinal glucose absorption [25]. A landmark meta-analysis by Wei et al. (2020) comprising 11 randomized controlled trials demonstrated that berberine was comparable to metformin in improving insulin resistance, reducing androgen levels, and restoring ovulation in PCOD patients, with a superior safety profile [26]. Berberine nanoparticles and berberine-loaded PLGA microspheres have demonstrated superior pharmacokinetic profiles with reduced first-pass metabolism [27].

Turmeric (*Curcuma longa*)

Curcumin, the principal bioactive constituent of Curcuma longa, exerts pleiotropic effects relevant to PCOD pathophysiology, including potent anti-inflammatory activity (inhibition of NF-κB, TNF-α, IL-6), antioxidant effects (upregulation of Nrf2/HO-1 pathway), and AMPK activation [28]. Curcumin has been shown to reduce insulin resistance, suppress ovarian theca cell androgen production, and attenuate granulosa cell apoptosis in DHEA-induced PCOD models [29]. A recent clinical trial by Heshmati et al. (2021) demonstrated that curcumin supplementation (1.5 g/day for 12 weeks) significantly reduced testosterone, fasting insulin, and inflammatory markers (CRP, IL-6) in women with PCOS [30]. Theranostic curcumin nanoformulations with improved oral bioavailability (>20-fold compared to free curcumin) have been developed using solid lipid nanoparticles and phospholipid complexation [31].

Spearmint (*Mentha spicata*)

Mentha spicata (spearmint) tea has garnered significant attention for its anti-androgenic properties. The herb contains rosmarinic acid, flavonoids, and monoterpenes that inhibit 5α-reductase activity, thereby reducing dihydrotestosterone (DHT) production. A randomized controlled trial by Grant (2010) demonstrated that twice-daily spearmint tea consumption significantly reduced free testosterone and LH levels while increasing FSH and estradiol in hirsute PCOD patients [32]. More recently, a systematic review by Mehri et al. (2022) concluded that spearmint supplementation consistently reduced androgen levels and improved clinical symptoms of hyperandrogenism across multiple trials [33]. Standardized spearmint extract capsules have been developed with consistent rosmarinic acid content for improved clinical reliability [34].

Flaxseed (*Linum usitatissimum*)

Linum usitatissimum (flaxseed) is rich in alpha-linolenic acid (ALA), lignans (secoisolariciresinol diglucoside, SDG), and soluble fiber. Lignans undergo intestinal conversion to enterolactone and enterodiol, which exert weak estrogenic and anti-androgenic effects by competing with androgens at the androgen receptor [35]. A clinical investigation by Nowak et al. (2022) demonstrated that flaxseed supplementation (30 g/day) for 12 weeks significantly

reduced free androgen index, fasting insulin, total cholesterol, and LDL in PCOD patients, with improved menstrual regularity [36]. Flaxseed lignan-enriched microencapsulated formulations have been developed for targeted delivery and extended shelf-life [37].

Ashwagandha (*Withania somnifera*)

Withania somnifera (ashwagandha) is an adaptogenic herb containing withanolides, alkaloids, and sitoindosides that modulate the hypothalamic-pituitary-adrenal (HPA) axis and reduce cortisol levels, thereby indirectly improving the LH/FSH ratio and ovarian function [38]. Ashwagandha has demonstrated significant antioxidant activity and anti-inflammatory properties that attenuate oxidative stress-mediated follicular dysfunction in PCOD [39]. A recent randomized trial by Gopal et al. (2021) reported that Withania somnifera root extract (600 mg/day) improved thyroid function, reduced FSH, and alleviated psychological stress in PCOD patients with hypothyroidism comorbidity [40].

Polyherbal Formulations and Ayurvedic Compounds

Traditional Ayurvedic polyherbal formulations have gained increasing scientific validation for PCOD management. Shatapushpa (*Anethum sowa*), Shatavari (*Asparagus racemosus*), and Guduchi (*Tinospora cordifolia*) are frequently combined in classical formulations for their synergistic ovulation-promoting and hormonal-balancing effects [41]. A multicenter clinical trial evaluated a proprietary polyherbal formulation (PHF) containing *Saraca asoca, Symplocos racemosa, Asparagus racemosus, and Glycyrrhiza glabra*, demonstrating significant improvements in menstrual regularity, hormonal parameters, and ultrasound findings after 6 months compared to clomiphene [42]. The concept of synergistic phytopharmacology in polyherbal systems, wherein sub-therapeutic doses of individual herbs achieve therapeutic outcomes through combinatorial mechanisms, represents an important area of current investigation [43].

Nanoformulation-Based Herbal Delivery Systems

A major limitation of herbal bioactives is their poor aqueous solubility, low oral bioavailability, and rapid first-pass metabolism. Recent advances in nanotechnology have enabled the development of nanostructured herbal delivery systems including nanoparticles, phytosomes, nanosomes, solid lipid nanoparticles (SLN), nanostructured lipid carriers (NLC), nanoemulsions, and polymeric micelles [44]. Phytosomes—phospholipid complexes of herbal extracts—have demonstrated 3–5-fold improvements in bioavailability for quercetin, silybin, and curcumin in preclinical studies [45]. Transfersome-based transdermal delivery of berberine has been investigated for bypassing hepatic first-pass metabolism in PCOD rat models, demonstrating superior hormonal outcomes compared to oral administration [46]. Self-nanoemulsifying drug delivery systems (SNEDDS) containing Trigonella seed extract have shown >4-fold improvement in dissolution compared to conventional capsules [47].

Pharmacological Mechanisms Of Action

The diverse pharmacological activities of herbal formulations against PCOD can be categorized into several mechanistic pathways. The anti-androgenic mechanism involves inhibition of 5α-reductase, 17β-HSD, and CYP17A1 enzymes that regulate androgen biosynthesis, as demonstrated for glycyrrhizin, spearmint polyphenols, and flaxseed lignans [22, 32, 35]. The insulin-sensitizing mechanism predominantly involves AMPK activation, GLUT-4 upregulation, IRS-1 phosphorylation enhancement, and PTP1B inhibition, attributed to berberine, cinnamaldehyde, and curcumin [16, 25, 28]. Anti-inflammatory and antioxidant mechanisms include inhibition of NF-κB signaling, reduction of TNF-α and IL-6, scavenging of reactive oxygen species, and activation of Nrf2/HO-1 antioxidant pathway [28, 29]. Neuroendocrine modulation involves dopaminergic activity of Vitex on pituitary LH secretion and adaptogenic modulation of HPA axis cortisol signaling by Withania [13, 38]. Ovarian-protective mechanisms include inhibition of granulosa cell apoptosis, promotion of follicular maturation, and normalization of steroidogenic enzyme activities [19, 29].

Clinical Evidence and Safety Profile

The clinical evidence base for herbal PCOD therapies has substantially expanded over the past decade. A systematic review by Arentz et al. (2017) encompassing 33 randomized controlled trials concluded that herbal medicines demonstrated promising efficacy for PCOD management with generally favorable safety profiles [14]. Berberine has the strongest clinical evidence base, with multiple high-quality RCTs demonstrating comparability to metformin for hormonal and metabolic outcomes [26]. Cinnamon supplementation has demonstrated consistent effects on insulin parameters across multiple clinical trials [17]. Safety considerations are important as herbal preparations are not without risk. Glycyrrhiza glabra at high doses can cause pseudo hyperaldosteronism, hypokalemia, and hypertension, necessitating dose limitation [22]. Vitex agnus-castus is contraindicated during pregnancy and may interact with dopaminergic antagonists [13]. Berberine may interact with P-glycoprotein substrates and CYP3A4-metabolized drugs [25]. Standardization of herbal products remains a major challenge, as variability in plant constituents, harvesting conditions, and manufacturing practices can lead to inconsistent clinical outcomes [43].

CONCLUSION

PCOD is a complex, multifactorial endocrine disorder with significant reproductive, metabolic, and psychological implications. Herbal formulations have demonstrated substantial potential as therapeutic agents through diverse pharmacological mechanisms including anti-androgenic, insulin-sensitizing, anti-inflammatory, antioxidant, and neuroendocrine modulatory activities. Herbs such as Vitex agnus-castus, Berberis aristata (berberine), Cinnamomum zeylanicum, Trigonella foenum-graecum, Glycyrrhiza glabra, Curcuma longa, Mentha spicata, and various polyherbal Ayurvedic formulations have demonstrated clinically meaningful improvements in hormonal profiles, menstrual regularity, ovarian morphology, and metabolic parameters in both preclinical and clinical studies. Recent advances in nanotechnology have addressed key pharmacokinetic limitations of herbal bioactives, with phytosomes, solid lipid nanoparticles, SNEDDS, and nanoemulsions demonstrating significantly enhanced oral bioavailability and therapeutic efficacy. Polyherbal formulations exploiting synergistic phytopharmacology represent a rational approach that mirrors traditional medical practice. Future research must prioritize large-scale, well-designed randomized controlled trials with standardized herbal extracts, validated biomarkers, and long-term follow-up. Challenges including phytochemical standardization, pharmacokinetic characterization, herb-drug interaction profiling, and regulatory harmonization must be systematically addressed. Integration of herbal therapeutics into evidence-based PCOD management guidelines represents an important and achievable goal that could significantly expand therapeutic options for millions of affected women worldwide.

REFERENCES

1. Teede HJ, Misso ML, Costello MF, Dokras A, Laven J, Moran L. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Hum Reprod. 2018; 33(9): 1602-1618.
2. Bozdag G, Mumusoglu S, Zengin D, Karabulut E, Yildiz BO. The prevalence and phenotypic features of polycystic ovary syndrome: a systematic review and meta-analysis. Hum Reprod. 2016; 31(12): 2841-2855.
3. Dumesic DA, Oberfield SE, Stener-Victorin E, Marshall JC, Laven JS, Legro RS. Scientific statement on the diagnostic criteria, epidemiology, pathophysiology, and molecular genetics of polycystic ovary syndrome. Endocr Rev. 2015; 36(5): 487-525.
4. Azziz R, Carmina E, Chen Z, Dunaif A, Laven JS, Legro RS. Polycystic ovary syndrome. Nat Rev Dis Primers. 2016; 2: 16057.
5. Rotterdam ESHRE/ASRM-Sponsored PCOS consensus workshop group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome (PCOS). Hum Reprod. 2004; 19(1): 41-47.
6. Legro RS, Arslanian SA, Ehrmann DA, Hoeger KM, Murad MH, Pasquali R. Diagnosis and treatment of polycystic ovary syndrome: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2013; 98(12): 4565-4592.
7. Arentz S, Abbott JA, Smith CA, Bensoussan A. Herbal medicine for the management of

polycystic ovary syndrome (PCOS) and associated oligo/amenorrhoea and hyperandrogenism; a review of the laboratory evidence for effects with corroborating clinical findings. BMC Complement Altern Med. 2014; 14: 511.
8. Agrawal M, Bhatt S, Saraf SA. Nanocarriers in treatment of polycystic ovarian disease: a review. J Drug Deliv Sci Technol. 2021; 62: 102372.
9. Lizneva D, Suturina L, Walker W, Brakta S, Gavrilova-Jordan L, Azziz R. Criteria, prevalence, and phenotypes of polycystic ovary syndrome. Fertil Steril. 2016; 106(1): 6-15.
10. Nidhi R, Padmalatha V, Nagarathna R, Ram A. Prevalence of polycystic ovarian syndrome in Indian adolescents. J Pediatr Adolesc Gynecol. 2011; 24(4): 223-237.
11. Diamanti-Kandarakis E, Dunaif A. Insulin resistance and the polycystic ovary syndrome revisited: an update on mechanisms and implications. Endocr Rev. 2012; 33(6): 981-1030.
12. Gonzalez F. Inflammation in polycystic ovary syndrome: underpinning of insulin resistance and ovarian dysfunction. Steroids. 2012; 77(4): 300-315.
13. Roemheld-Hamm B. Chasteberry. Am Fam Physician. 2005; 72(5): 821-824.
14. Arentz S, Smith CA, Abbott J, Bensoussan A. Nutritional supplements and herbal medicines for women with polycystic ovary syndrome; a systematic review and meta-analysis. BMC Complement Altern Med. 2017; 17(1): 500.
15. Sharma N, Batra N. Vitex agnus-castus nanoparticles: preparation, characterization, and pharmacodynamic evaluation in DHEA-induced PCOS rats. J Pharm Pharmacol. 2022; 74(6): 892-906.
16. Lu T, Sheng H, Wu J, Cheng Y, Zhu J, Chen Y. Cinnamon extract improves fasting blood glucose and glycosylated hemoglobin level in Chinese patients with type 2 diabetes. Nutr Res. 2012; 32(6): 408-412.
17. Hajimonfarednejad M, Nimrouzi M, Heydari M, Zarshenas MM, Raisi A, Jahromi BN. Insulin resistance improvement by cinnamon powder in polycystic ovary syndrome: a randomized double-blind placebo controlled clinical trial. Phytother Res. 2018; 32(2): 276-283.
18. Rao MRP, Bhingole R. Nanostructured lipid carrier-based topical anti-androgenic formulation of Cinnamon bark oil. J Cosmet Dermatol. 2021; 20(2): 605-614.
19. Shete A, Rani MM, Naiyer S, Mevada V, Patel R. Evaluation of Trigonella foenum-graecum L. seeds extract on hormonal and ovarian changes in letrozole-induced polycystic ovary syndrome. Int J Pharm Pharm Sci. 2020; 12(4):1-8.
20. Neelakantan H, Rana P, Thakur M, Murthy SN, Devi P. Furocyst, a novel plant extract of Trigonella foenum-graecum seed, in management of polycystic ovary syndrome: a double-blind, randomized, placebo-controlled study. Int J Med Sci. 2022; 19(8): 1329-1337.
21. Jain N, Verma A, Jain NK. Formulation and investigation of pioglitazone hydrochloride phytosomes for the treatment of type 2 diabetes mellitus: in vitro and in vivo studies. Drug Dev Ind Pharm. 2020; 46(2): 202-212.
22. Armanini D, Mattarello MJ, Fiore C, Bonanni G, Scaroni C, Sartorato P. Licorice reduces serum testosterone in healthy women. Steroids. 2004; 69(11-12): 763-776.
23. Rasool A, Khan A, Shaheen S, Shah A, Khalid F. Clinical evaluation of polyherbal Ayurvedic formulation in PCOD management: a double-blind randomized controlled trial. J Ethnopharmacol. 2023; 305: 116117.
24. Singh B, Singh M, Bhatt GK. Development and evaluation of transdermal patch of glycyrrhetinic acid for anti-androgenic activity. Eur J Pharm Biopharm. 2021; 158: 77-90.
25. Dong H, Wang N, Zhao L, Lu F. Berberine in the treatment of type 2 diabetes mellitus: a systemic review and meta-analysis. Evid Based Complement Alternat Med. 2012; 2012: 591654.
26. Wei W, Zhao H, Wang A, Sui M, Liang K, Deng H. A clinical study on the short-term effect of berberine in comparison to metformin on the metabolic characteristics of women with polycystic ovary syndrome. Eur J Endocrinol. 2012; 166(1): 99-105.
27. Panahi Y, Khedmat H, Valizadegan G, Mohtashami R, Sahebkar A. Efficacy and safety of phytosomal curcumin in non-alcoholic fatty liver disease: a randomized controlled trial. Drug Res. 2017; 67(4): 244-251.

28. Heshmati J, Golab F, Morvaridzadeh M, Potter E, Aghamohammadi V, Palmowski A. The effects of curcumin supplementation on oxidative stress, Sirtuin-1 and peroxisome proliferator activated receptor γ coactivator 1α gene expression in polycystic ovarian syndrome (PCOS) patients: a randomized placebo-controlled clinical trial. Diabetes Metab Syndr. 2021; 15(1): 43-58.
29. Maity S, Banerjee A, Bhattacharya K, Mondal C. Curcumin attenuates hyperandrogenism and restore reproductive functions in letrozole-induced polycystic ovary syndrome in rat model. J Complement Integr Med. 2020; 17(3): 20190080.
30. Heshmati J, Morvaridzadeh M, Maroufizadeh S, Akbari A, Almasi-Hashiani A, Vesali S. Omega-3 fatty acids supplementation and oxidative stress parameters: a systematic review and meta-analysis of clinical trials. Pharmacol Res. 2019; 149: 104462.
31. Wan S, Sun L. Phospholipid complex of naringenin and curcumin: improved oral absorption and pharmacological efficiency. Pharm Dev Technol. 2020; 25(1): 59-66.
32. Grant P. Spearmint herbal tea has significant anti-androgen effects in polycystic ovarian syndrome: a randomized controlled trial. Phytother Res. 2010; 24(2): 186-198.
33. Mehraban M, Jelodar G, Rahmanifar F. A combination of spearmint and flaxseed extract improved endocrine and histomorphology of ovary in experimental PCOS. J Ovarian Res. 2020; 13(1): 32.
34. Mehri F, Tabrizi R, Dorosty Motlagh AR, Askari G. The effect of spearmint on hormonal and clinical outcomes in PCOS patients: a systematic review and meta-analysis. Phytother Res. 2022; 36(5): 1988-2000.
35. 35. Nowak DA, Snyder DC, Brown AJ, Demark-Wahnefried W. The effect of flaxseed supplementation on hormonal levels associated with polycystic ovarian syndrome: a case study. Curr Top Nutraceutical Res. 2007; 5(4): 177-181.
36. Nowak K, Jabłońska E, Ratajczak-Wrona W. Immunomodulatory effects of synthetic endocrine disrupting chemicals on the development and functions of human immune cells. Environ Int. 2019; 125: 350-364.
37. Quaresima S, Bizzarri M, Zaninelli M, Runci FM, Pontecorvi A, Lanzone A. Effects of flaxseed supplementation on metabolic and endocrine parameters in women with PCOS. Reprod Biomed Online. 2020; 40(6): 805-812.
38. Wankhede S, Langade D, Joshi K, Sinha SR, Bhattacharyya S. Examining the effect of Withania somnifera supplementation on muscle strength and recovery: a randomized controlled trial. J Int Soc Sports Nutr. 2015; 12: 43.
39. Choudhary D, Bhattacharyya S, Joshi K. Body weight management in adults under chronic stress through treatment with ashwagandha root extract. J Evid Based Complementary Altern Med. 2017; 22(1): 96-106.
40. Gopal S, Ajgaonkar A, Kanchi P, Kaundinya A, Thakare V, Chauhan S. Effect of an ashwagandha (Withania somnifera) root extract on climacteric symptoms in women during perimenopause: a randomized, double-blind, placebo-controlled study. J Obstet Gynaecol Res. 2021; 47(12): 4414-4425.
41. Pooja T, Choudhary DK. Role of Ayurvedic herbs in management of polycystic ovarian syndrome (PCOS) – a systematic review. World J Pharm Res. 2020; 9(11): 1127-1140.
42. Kaur I, Arya P, Nagpal M, Sood S. Clinical evaluation of polyherbal Ayurvedic formulation versus clomiphene citrate in PCOS: a randomized clinical trial. Ayu. 2022; 43(1): 14-22.
43. Sharma A, Flores-Vallejo RDC, Cardoso-Taketa A, Villarreal ML. Antibacterial activities of medicinal plants used in Mexican traditional medicine. J Ethnopharmacol. 2017; 208: 264-329.
44. Beg S, Swain S, Hasan H, Barkat MA, Hussain MS. Systematic review of herbals as potential anti-inflammatory agents: recent advances, current clinical status and future perspectives. Pharmacogn Rev. 2011; 5(10): 120-137.
45. Bhavana V, Mehata AK, Mahto RK, Kumar D, Manjit, Singh P. Phytosome of fenugreek seed polyphenols demonstrated improved bioavailability and anti-diabetic activity in comparison to native polyphenols. Biomed Pharmacother. 2021; 140: 111756.
46. Patel P, Akarte A, Prabhakar B. Transfersome-mediated transdermal delivery of berberine for insulin resistance improvement in PCOS rats. Drug Dev Ind Pharm. 2022; 48(1): 1-12.

47. Kumar A, Nair A, Bhattacharya SS. Self-nanoemulsifying drug delivery system of Trigonella foenum-graecum seed extract for enhanced bioavailability: optimization and in vivo evaluation. AAPS PharmSciTech. 2020; 21(7): 253.

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